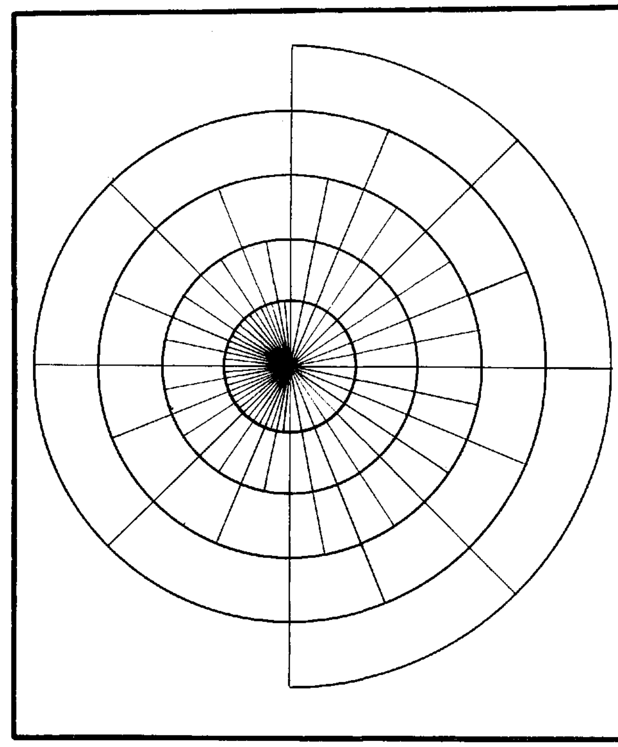
USE OF EXPLOSIVES IN COAL AND OIL FIELDS

By BRYCE O. REAY, '30

DYNAMITE has been termed The New Aladdin's Lamp. If one would take a little time to investigate the history and development of dynamite and to look into the possibilities of its future, I am sure that Aladdin's lamp would not even be considered as being in the same class. A short survey of what has been done with dynamite and a detailed description of one or two of its major present-day uses will enlighten the aspiring explosive engineer and many others that may be interested.

After noting the rapid growth of our country for the last seventy-five or eighty years as contrasted with those hundreds of preceding years and then after investigating the initial cause of these differences I think we will agree with Mr. T. W. Bacchus, vice-president of the Hercules Powder Company, when he classes dynamite as one of the greatest instruments of progress of the last half cenutry. To support his statement he points to the vast differences in methods and speeds of transportation and the the present-day mining methods. Tunnels have been bored through mountains. Hills have been cut away or entirely removed. Rock has been quarried for use in road construction and for the supplying of cement and building stone. Mine production has been greatly increased, thereby reducing the cost of power and materials used in mechanical construction. Since the use of explosives has become more general, the output of every mining industry, including oil and gas wells, has been greatly increased.

Early explosives that were used were very dangerous and many men lost their lives by the premature activity of such explosives. Failure to get away in due time from the vicinity of a shot also caused many deaths. However, in the years that followed safety devices were invented and



GRAPHICAL EXPLOSIONS

The above diagram illustrates how cushioning changes the action of a permissible so that this approaches that of black blasting powder. The center indicates the bore hole, the left half represents the action of an uncushioned permissible, and the right half that of black powder or a cushioned permissible. The radiating lines represent the forces produced on explosion. Where the lines are concentrated the shattering action is greatest. The nearer the lines of forse on the left hand half of the diagram can be made to simulate those on the right, the nearer will the action of a permissible approach that of black blasting powder.

safety precautions were developed and set down as rules. Now the explosive engineer who "knows his explosives" can avoid distastrous results. Dynamite is powerful and dangerous, but its power is being harnessed and hazards in its use are being eliminated. It is a vast store of energy ready to act at the snap of a finger and which may be devastating or which may be an aid to man. Brain versus brawn again and, as has ever been the case, human intelligence has been and is turning explosives into obedient servants.

Deep-Hole Blasting

By far the greatest portion of explosives used in well shooting is for production. This may be in an attempt to make a dry well produce, to increase the production of a new well, or to stimulate the production of an old well. Until recently it has not been a practice to shoot gas or water wells to increase production. Numerous instances, however, are known where shooting of gas and water wells has greatly increased their

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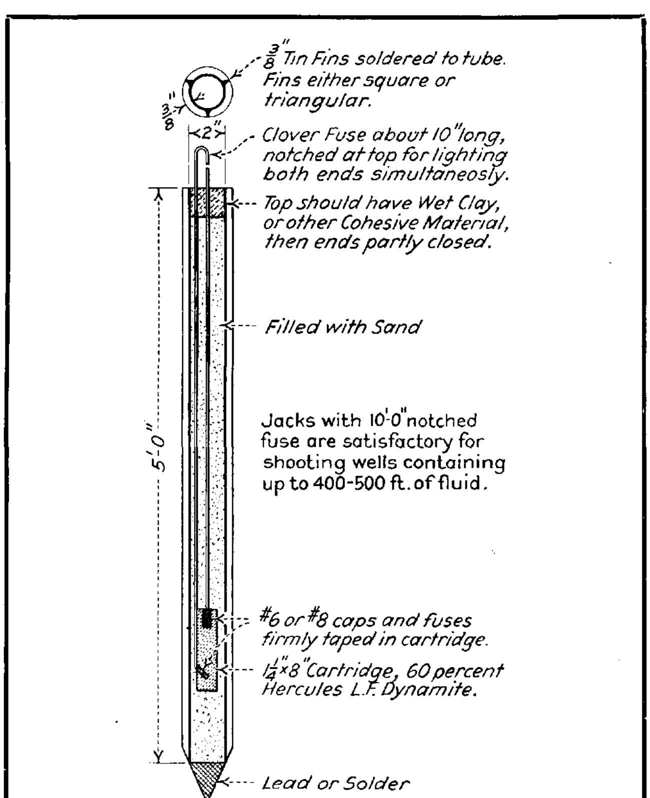

Fig. 1—A Jack-Squib

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production. In any case it is necessary to make a a careful study of the nature of the producing strata and the surrounding conditions before deciding whether to shoot it or not.

Formerly, nitro-glycerine was used more commonly for oil-well shooting. The immensity of its speed and the enormity of its strength made it highly desirable for that purpose. Its extreme sensitiveness to friction, impact and heat causes it to be easily detonated. In one way it is desirable for oil-well shooting because of the simple means of detonation; but in another way it is extremely dangerous and often exacts a toll of human lives.

A much safer explosive has been developed in the form of a plastic gelatin and may be readily packed firmly into the torpedo shells. Although precautions must be taken in the handling of this explosive as well as in handling others, it is not nearly so dangerous as the liquid nitroglycerin. If it is transported in accordance with the I. C. C. regulations it is considered very safe.

After deciding to shoot a well the first operation should be a careful study of the drilling log of the well to ascertain the exact depth and thickness of the producing formation and of the depth of the well below its productive formation. The torpedo shell is carefully loaded by firmly tamping plastic gelatin with charges of 60% L. F. straight nitroglycerine dynamite distributed in it. When loaded, the bail is placed over a special hook, attached to a ¼-inch manila rope line, and the shell is lowered down the hole. When in position a little slack is allowed on the line and by a few motions the shell will unhook and the freed line may be raised. When several shells are required they may be lowered in succession as above outlined and one allowed to rest above the other.

When the torpedoes are not to be placed in the bottom of the hole, tinned iron tubing, about 1¼ inches in diameter and of proper length, is connected to the first shell to act as a support for raising the charge to the proper point. The torpedo shells are usually about one inch in diameter smaller than the diameter of the hole. For most effective results the length of the torpedo should extend through the entire length of the productive formation. If the productive formation is sonsiderable distance from the bottom of the hole the hole should be bridged a short distance below the productive formation. A convenient method of doing this is to lace two pieces of cable through a torpedo shell so that the cable will act as a spring in holding the shell at any position. It is lowered to the desired location and then two or three feet of small rocks are carefully thrown into the hole to form a solid foundation for the torpedoes.

After the charge is lowered to the place desired it is fired with a squib. The most common and effective squib to use with the torpedo explosive is the jack squib, or else a type of electric squib.

The jack squib is suitable for use in open holes where there is no danger of caving formation or where it is not necessary to remove the casing because of proximity to formations to be shot.

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The squib is a tinned iron tube two inches in diameter and from three to six feet in length. An average length which is considered very satisfactory is about five feet. Ribs of tinned iron are soldered along the outside of the tube to reinforce it against the wear in rubbing against the sides as it drops down the hole. The squib is weighted either by making it with cast iron tip or filling the cone with solder or lead. This gives the squib a more certain and direct action in traveling down the hole, especially in holes containing considerable fluid.

Figure 1 illustrates the details of the construction and loading of a common type of jack squib. A 1¼x8-inch cartridge of 60% L. F. straight nitroglycerin dynamite, primed with two No. 6 or No. 8 blasting caps, with proper lengths of fuse, is packed in sand near the bottom of the tube. The tube is then filled with sand to within about six inches of the top. The connections of the cap and fuse, as well as the dynamite cartridge, should be carefully taped to make them water-proof.

The length of the fuse depends on the depth of the hole. Five feet of fuse for each blasting cap is a convenient size and is satisfactory in most cases. Although it is by no means definite, usual practice considers one foot of clover fuse per 1,000 feet of drop through a dry hole and three feet of fuse per 1,000 feet of drop through water or free flowing oil, as sufficient.

Instances are known where jack squibs have been satisfactorily used in wells containing 1,000 feet of liquid. However, it is generally preferred not to use a jack squib where the fluid is over 600 feet in depth.

Cushioned Blasting in Coal Mines

Since permissible explosives first came into use shortly after 1910, many operators, who substituted them for black powder in gaseous and dusty mines, have felt that they could not be made to yield the same good results in percentage of lump coal production. This was true until a method of cushioning the permissible was developed. After rock-dust stemming and air-space cushioning were developed it was found that the action of the permissible is equally as efficient in lump coal production as black powder formerly was. Each of these two methods of cushioning produce good results, but the former is considered much safer.

Figure 2 illustrates how cushioned blasting probably changes the action of permissible explosives so that it approaches the action of black blasting powder. The bore hole, with the explosive charge, is in the middle. The radiating lines represent the forces produced when the charge is exploded. The left half of the diagram shows the action of permissible which has been used without cushioning; the right half that of black powder or of a cushioned permissible. It is seen that the highest concentration of radiating lines is in the immediate vicinity of the explosive, which means that the shattering action will be greatest at that point, while as the distance increases it becomes less. The total length of lines in a given section is a measure of the energy acting on the coal; in the case of black powder there is less concentration of the short shattering lines close to the charge. This is due to the lower rate of explosion as the explosive tends to act longer through greater distances. The nearer the lines of force on the left side of the diagram can be made to simulate those on the right, the nearer the action of permissible will approach the action of black powder. This is being done, as shown by the diagram, by cushioning the permissible explosive.

That cushioning permissibles is sound from the theoretical point of view is evident as is seen by the following table which was compiled by Mr. J. Barab. He compares the properties of FFF black blasting powder with a comparatively fast permissible.

	FFF black blasting powder	*Comparatively fast permissible*
U. D. C.	458	218
Velocity, ft. per sec.	1,540	10,380
Spec. grav. by sand	1.25	1.12
Max. pressure developed in lbs. per sq.in.	68,509	125,800

It can be seen that the maximum pressure developed by the permissible listed above is twice that listed for black powder. One U. D. C. of the latter occupies 1.88 times the volume of one U. D. C. of the former. The law of thermodynamics states that $PV = RT$, where P is the pressure, V is the volume, R is a constant, and T is the temperature. Assuming the temperature as remaining constant, then PV is a constant and P is equal to $\frac{\text{Constant}}{V}$. This shows that by doubling the loading volume of the above permissible the maximum pressure developed is reduced inversely in the same proportion, to 62,000 pounds per sq. in., which is very close to the maximum pressure developed by black powder.

By increasing the volume, the effect on the coal of the permissible's high velocity of detonation is also reduced. Therefore if a low velocity permissible is chosen and fired by cushioning its effects will often approach very closely those of black powder.

To get a high percentage of lump coal, the drilling and undercutting must always be done with care, no matter whether black blasting powder or permissibles are used. Frequently permissibles seem to be giving poor results merely because these two important factors are not being watched properly.

When rib holes are drilled at such an angle that the end of the hole extends for a considerable distance into the sidewalls, a much heavier charge is needed, which will probably shatter the coal badly. When a miner fails to pull coal with the usual charge, it is often due to the fact that he has drilled the hole too far into the sidewall.

The purpose of the undercutting machine is to give the coal an additional free face. By doing this the explosives are only required to shear the coal on four sides. Quite frequently the back of a cut is not pulled because the far corners are left round instead of being undercut squarely.